



LAWRENCE  
LIVERMORE  
NATIONAL  
LABORATORY

# The "Athena Framework": Solving the World-wide Climate and Energy Problem

J. C. S. Long

October 10, 2005

L20 Energy Security Workshop  
Palo Alto, CA, United States  
October 13, 2005 through October 14, 2005

## **Disclaimer**

---

This document was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor the University of California nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or the University of California, and shall not be used for advertising or product endorsement purposes.

# **The "Athena Framework": Solving the World-wide Climate and Energy Problem**

*Jane C. S. Long*

*This work was performed under the auspices of the U.S. Department of Energy by University of California, Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.*

---

## **INTRODUCTION:**

The energy systems we have enjoyed for the last 100 years has resulted in the advanced standard of living in the developed world and a major emerging problem with climate change. Now we face a simultaneous realization that our reliance on fossil fuels is a source of conflict and economic disruption as well as causing potentially catastrophic global climate change. It is time to give serious thought to how to collectively solve this problem. Collective action is critical since individual effort by one or only a few nations cannot adequately address the issue.

The climate and energy problem is perhaps the greatest challenge ever faced by mankind. Fossil fuel remains the least expensive and most available source of energy and the basis of our economy. The use of fossil fuels, especially over the last 100 years has led to a 30% increase in CO<sub>2</sub> in the atmosphere and observable global warming. The problem is growing. The population of the Earth will increase by several billion people in the next 50 years. If economic growth is to continue, the demand for energy is estimated to approximately double in the next 50 years so that we will need approximately 10 TW more energy than the 15 TW we use now. Much of this demand will come from the developing world where most of the population growth will occur and where advanced energy technology is not generally used.

The problem affects and is affected by a complex system of systems. The climate and energy problem will affect resources, social structure and the probability of increased conflict. It is the first time that the actions of each and every individual on Earth affect everyone else -- where the choice to drive an SUV in the U.S. affects the availability of water in the Himalayas, where building massive amounts of coal-fired power plants in China will cause flooding in Bangladesh and drought in California. This problem connects all the people of the world like no other problem has before. No one person, no one nation, no one technology can solve the problem. There is no parallel precedent on which to model a solution. We need a major worldwide effort on a scale never before attempted. The future of life on Earth may well depend on the outcome.

Near the end of World War II, an elite group of scientists retreated to the hills of New Mexico to develop the atomic bomb in response to a clear and present danger. The Manhattan Project gathered the best minds to put intense effort into a solution. It is no wonder that the phrase "We need a Manhattan Project for energy" is increasingly seen in commentary. The "Manhattan Project" concept is used to invoke the need for an all-out,

focused effort on solving an urgent problem to a clear and present danger. In this regard, a “Manhattan Project is exactly what we need.

However, there are aspects of the Manhattan Project that are antithetical to the solutions we will have to find for the climate and energy problem. For this problem, the solution will require unprecedented collaboration between governments, scientists and citizens. The results should be highly transparent and by no means secret. Looking back on the Manhattan Project, we realize that it released a terrible new force on the world with great potential for evil. We cannot afford such a mixed outcome for climate. In fact, the solution is international and not even a “project” in the sense that a project has a clear scope, and beginning and an end. The solution in this case will be a long-term continuous effort over many years.

So, what should we call this effort to solve the most critical problem the world faces today? We propose the “Athena Framework” as a working name. Athena was a goddess of wisdom and strategy, both badly needed in this effort. She was also a warrior and by using her name we invoke a battle for life – as we know it -- on Earth. Whether this name sticks or another is chosen, the point is that the effort needs the identity of a name to help to draw people to the solution.

Fundamentally solving the climate and energy problem is a matter of societal choice. Do we continue business as usual, or do we make rational decisions that increase the likelihood of survival? We need a “framework” for making these decisions. We need to base these decisions on the best possible understanding of the systems we are dealing with. We need to realize that no matter what we do now, there will be significant and harmful outcomes from climate change already underway. We need to develop a strategy for anticipating and responding to these changes. As we look to stop this downward spiral, there are many solutions, each of which cuts a wedge into the problem and none of which can solve the problems on their own. However, each stab at the problem connects to many other issues. Nuclear power creates no greenhouse gasses, but produces radioactive waste. Hydrogen fueled cars do not emit greenhouse gases, but the production of hydrogen from fossil fuel does. The use of fossil fuel has created the enormous economic wealth in the developed world and as well created tremendous threats to security with two-thirds of the known oil supplies in the Middle East. China plans to increase power production by 1000MW per week largely with coal-fired plants and India plans a similar if smaller campaign. Solving the climate problem requires solving the problem in China and India, not just in the industrialized West. Without addressing climate change technology in the context of security, resilience, economics and development, solutions are unlikely to be realistic. A framework is needed to examine the choices in light of its connections to other issues and unintended consequences.

What does the Athena Framework look like? What does the world have to do to solve these problems? We need to examine the key actors and the key tasks. The actors are:

**Society:** We face a tremendous dearth of scientific literacy that would allow citizens to evaluate scientific information adequately and permit citizens to act responsibly. It is fundamentally a series of societal choices that will decide the outcome of climate change. We face the challenge to inform those choices in this country where scientific literacy is declining and declining numbers of our students choose to study science and engineering. As

society does a better job of understanding the causes and effects of climate change, they can drive better policy.

**Policy makers:** Policy makers can create incentives, regulations and agreements that are critical to driving change in our energy systems. James Schlesinger remarked in 1989 that the U.S. has two approaches to energy policy, complacency or panic. How can we find the middle ground of rational decision-making? It is hard to even get stakeholders to the table as many are unwilling to even enter the conversation about what to do because they fear consequences of dealing with the problem are dire. People don't agree about what the problem is, never mind the solution. Also at the heart of the problem is the need for a global solution and the lack of any global institution capable of affecting a solution. If the developing world is further disadvantaged by our energy choices, global conflict will increase. In this environment policy makers must be urged to take a long-view and to find ways of dealing with complex issues without oversimplification. The long-view has a time scale of history, not the election cycle.

**Scientists and engineers:** Technology can help us to understand, prepare and advance but scientists must find ways to overcome institutional barriers to important collaborations and must be urged out of "admiring the problem" as opposed to solving it. They need to do a better job educating the public about their results and taking cues from policy makers about their needs. Scientists need to learn to communicate risks appropriately and engineers need to understand how technology moves from the lab to deployment.

**Industry:** Businesses will recognize the need for sustainable practice because they are responding to regulation or because they see it as an economic prerequisite for staying in business. In addition, they will be driven by societal values and they will drive policy to be uniform and predictable in order to control their business environment. These are all forces for the good. To be part of the solution, some businesses will have to be urged to abandon the "bunker mentality" of reacting to change as beleaguered and injured parties.

Each of these actors has a role in solving the problem. There are essentially three tasks the world must undertake:

1. **Understand the problem and predict outcomes:** It is the interaction of human behavior with the Earth's natural system that is at the heart of the climate and energy problem. We need to develop the scientific basis and capacity to understand how the natural system will behave in concert with human activity. How will temperature rise and what in turn will the temperature rise cause?
2. **Evaluate risks and adapt:** We need to have the foresight to prepare for and adapt to changes in our environment due global climate change. What changes can we expect and how shall we mitigate their negative effects? What actions should we take as insurance against probable dangers?
3. **Develop a clean energy system for the world:** Finally we must solve this problem by developing energy technologies that do not cause global climate change and are as well not a threat to security or economic well-being. Analysis shows that no one technology will solve all the problems. We need a portfolio of solutions that will allow us to provide clean energy to all peoples of the world.

Each of these three tasks is tabulated below. For each task, we discuss the reason there is an issue (“why”) and “what” might be done. Comments in the third column relate to the U.S. national program, and finally the last column provides comments applicable to the L20 Energy Security Workshop.

## Task 1 Understand the climate system in order to inform policy

Why	What	Comments	L20 Energy Security Workshop
<b>Climate models:</b> We cannot accurately predict the effect of future emissions on climate. We have no sophisticated models that can predict abrupt climate change as has been observed in the observational record. As abrupt climate change is a possibility, we need to understand how it could happen and with what certainty and impact.	Need research bio-geochemical cycles including carbon cycle Need regional-scale resolution and physics Need research to create such models and attempt validate against paleodata	Can be covered by CCSP if funded	This is a clear area where L20 nations can cooperate
<b>Data:</b> Our ability to understand what has happened in the past and what might happen in the future is inexorably linked to having uninterrupted and ubiquitous data of many types that can be cross-evaluated.	Create a national and international commitment to continuous data collection. Expand sampling, archiving and remote sensing as well as analysis and data-base management	Also potentially covered in CCSP. Needs funding commitment	This is a clear area where L20 nations can cooperate
<b>Education:</b> Most likely the tipping point on public opinion about climate change is near. But even if we begin to act now, we will not see progress on climate change for many generations. How will we insure that future generations maintain the societal will and discipline required for a long-term solution?	Need to develop educational curriculum and programs for K-12. Need to develop outreach programs and run public forums.	No program currently covers this.	Educational programs may be more advanced in countries such as UK where 90% of the people believe climate change and energy are problems.

**Task 2 Evaluate Risks and Adapt: We cannot stop climate change, how will we respond to inevitable problems?**

Why	What	Comments	<b>L20 ENERGY SECURITY WORKSHOP</b>
<p>We will face:</p> <ul style="list-style-type: none"> <li>✓ Decreasing fresh water supply, frequent droughts, and increasing water demand</li> <li>✓ Extreme events of deadly consequence such as heat waves, storms, floods and forest fires.</li> <li>✓ Disruptions to agriculture</li> <li>✓ Sea level increase, coastal erosion, melting of the permafrost</li> <li>✓ Decreased pH and warming of the oceans leading to ecological damage</li> <li>✓ Degraded air quality and migration of disease vectors</li> <li>✓ Ecological damage due to habitat loss</li> </ul>	<p>To mitigate these potential risks, need a new program to facilitate adaptation, based on:</p> <ul style="list-style-type: none"> <li>✓ estimates of increased risk due to climate change, and their costs</li> <li>✓ a wide range of technical and policy tools for dealing with the risks</li> <li>✓ estimates of the cost of mitigation</li> </ul>	<p>We have no national coordinated program to plan and execute adaptation. Need the CCFP: Climate Change Foresight Program.</p> <p>The problems are inherently regional in nature and local impacts must be assessed and addressed. Need to develop regional programs in cooperation with the Federal program</p>	<p>Adaptation technology can be shared among countries to minimize the cost of development.</p>
<p>Impacts of climate change will be disproportionately larger in the developing world. Security threats and conflict will increase as a result.</p>	<p>Need commitments from the industrialized world to assist the developing world. Potential G8 issue?</p>	<p>Need companion bill to Hagel's developing world technology bill to assist with adaptation.</p>	<p>L20 may be a good way to organize an international response.</p>

**Task 3 Create a new energy system: The problem is huge and will require multiple approaches to solution.**

Why	What	Comments	L20 Energy Security Workshop
<p><b>Policy:</b> We need a much more aggressive approach to developing a new energy system. We do not understand how our current energy system works and how policy, technology and resource changes will affect the economic aspects of the system, the security of energy and the climate system</p>	<p>Build a new generation of energy models that can predict the impacts of new technology adoption, proposed policy and economic forces. Policies such as</p> <ul style="list-style-type: none"> <li>✓ Cap and trade</li> <li>✓ Efficiency standards</li> <li>✓ Carbon tax</li> <li>✓ Incentives</li> <li>✓ Hydrogen economy</li> </ul> <p>must be evaluated for their effects on GHGs, economy and security</p> <p>Develop verification technology.</p>	<p>Form energy modeling consortia to develop modeling systems and address local, national and international scope issues. Carbon tax directed to support research.</p> <p>Industry will increasingly support carbon policies to establish predictable business climate &amp; to maintain competitive position.</p>	<p>The energy system is inherently international. We need global analysis, which might be done cooperatively.</p>
<p><b>Efficiency:</b> The most immediate response to our energy/climate problem is conservation and efficiency. (Goal 1 of CCTP) We need new technology to increase the use of waste energy, building efficiency technology (appliances, heating, cooling, lighting) and more efficient industrial processes and transportation.</p>	<ul style="list-style-type: none"> <li>✓ For cars and all products, model policy after the Japanese “ratchet” program where the leader in efficiency for each product type becomes the target for all who must meet it within 5 years.</li> <li>✓ For buildings, create a pathway to energy independent buildings. Create a national rotating fund for capital to replace future operating funds. Support states to create regionally appropriate building codes similar to LEEDS.</li> <li>✓ Require energy impact analyses as part of EIS requirements in land-use and transportation</li> </ul>	<p>All reasonable models for our future energy scenario that control GHG require a decreasing carbon intensity and greater energy efficiency. Extreme efficiency is a term of art that describes schemes to squeeze the last drop of</p>	<p>L20 countries can agree to share efficiency technology and share experience with policy.</p>

	projects. ✓ Develop efficient and desalination and waster use technology and policy to require efficiency.	energy out of all systems.	
<b>Carbon Capture and Storage:</b> We will be dependent of fossil fuel for some time and need to capture and sequester carbon.. An outgrowth of GHG is the acidification of the oceans, which may lead to wide spread ecological disaster. Carbon sequestration in the form of carbonate would buffer the oceans. Other GHG must be addressed as well. (CCTP Goal 3, 4)	We need advances in understanding how, how much and for how long geologic C-sequestration will work. We need efficient inexpensive capture technology We need innovative ideas for alternative C-Sequestration and the development of carbon sequestration schemes which also provide pH buffering in the Oceans Other GHG's such as methane are also important to control..	Use existing regional cooperatives. Industrial partnerships The carbon capture and storage program is vastly under-funded. Increase funding by at least an order of magnitude.	There is already an international group working on CCS.
<b>Energy Supply and Distribution Technology Development</b> (CCTP goals 2,5,6) We need a whole suite of new technologies that will transform energy supply, distribution and end use eliminating GHGs and maintaining our economy and security. <b>SEE Table 1 for an expansion of these issues</b>	Topics include: ✓ Renewables ✓ Nuclear Power ✓ Hydrogen <i>sans</i> carbon ✓ Transmission ✓ Distributed generation and energy storage ✓ Transportation <i>sans</i> carbon ✓ Transformational technology ✓ Energy for the developing world	Implementation issues include: ✓ Technology development ✓ Technology adoption ✓ Resource availability ✓ Life-cycle issues	Technology breakthroughs might be jointly developed. Nuclear power issues are inherently international because of non-proliferation and safety issues.

**Table 1 Energy Supply and Distribution Technology Development**

<b>Why</b>	<b>What</b>	<b>Comments</b>	<b>L20 Energy Security Workshop</b>
<b>Renewables</b> will play a role in reducing green house gases as well as in energy security and economic development	Each renewable has critical issues to overcome: ✓ Wind: land use, bird kills ✓ Geothermal: prospecting, enhancing the reservoirs, use of low temperature ✓ Biomass: non economical technology, some technology uses more energy than it gains ✓ Solar: Need to reduce the cost of solar photovoltaics from the current ~\$5,000 per kilowatt to ~\$1,000 per kilowatt.	Need programs to address critical issues that may not be supported by industry.  Create a national RPS supported by production tax credits and game-changing research.  Provide insurance for long-term power purchase to enable financing	Technology transfer will largely be through private industry
<b>Nuclear Power</b> does not produce greenhouse gases and could be an important part of climate change mitigation. The international community is moving ahead with this technology.	Increasing the contribution from nuclear energy will require managing the nuclear fuel cycle including nuclear waste and having safe and secure operations that are proliferation resistant.	Revise the U.S. nuclear power program to address systems issues in nuclear power, Revise Nuclear Waste Policy Act to address YMP issues	Requires international leadership, L20 is a likely candidate.
<b>Hydrogen:</b> The “hydrogen economy” will not contribute to the control of climate change unless we find ways to make hydrogen that do not use more energy than they produce and do not emit GHG.	Develop methods to obtain hydrogen fuels without releasing GHG. Hydrogen storage and the life of membranes in fuels cells are other issues.	Hydrogen cars do not produce GHGs, but the production of hydrogen from fossil fuel does. This is the controlling issue from a climate perspective.	Several L20 nations are considering hydrogen futures. The problems are the same.
<b>Transmission</b> Grid failures are likely unless better power electronics can be utilized to manage the load. As well, it would be very helpful to be able to	✓ Engineering design for re-engineering the grid to allow for more efficient power management and reliability.	There are severe issues with transmission policy as deregulation left much of the grid without anyone	Countries with common borders (e.g. Canada and US) share problems.

manage renewable intermittent power sources optimally. Superconducting grid would reduce line losses as well as allow distribution of remote renewable energy	✓ Development of low-cost, superconducting transmission..	responsible for maintenance and upgrade.	
<b>Distributed Generation and Energy Storage:</b> The world is moving inexorably towards distributed generation. To the extent that the source of energy is fossil fuels, distributed energy can also mean distributed emissions where there is no hope of sequestration or control. Energy storage technology would reduce the need for peak power and make intermittent renewables more useful	The development of distributed energy generation (DG) schemes that do not disseminate the emission of GHG or have a negative effect on health effect issues (particulates, Hg, NOx, Sox)  Develop small scale, low maintenance energy storage that costs less than ~\$100 per kilowatt-hour. Energy storage in the 1 to 15 kwh range would couple to distributed renewable energy production to reduce base load fossil plant needs.	Typical U.S. household requires about 1 kw average power or about 24 kwh per day with peak power capability of about 10 kw. In the developing world as little as 1 kwh energy storage would be useful for small PV systems or satellite beam power. U.S. household would need 10 to 15 kwh. Advanced batteries, flywheels, small scale SMES, hot rock are candidates	Technology transfer likely to be through private industry.
<b>Transportation:</b> Getting carbon emissions out of the transportation system is a major problem because we need to either have liquid fuels or develop the technology and infrastructure to use electricity. The hydrogen car is fine if the manufacturing of hydrogen for the fuel does not release GHG, or if that GHG can be sequestered.	✓ Comparison of liquid fuels ✓ Liquid fuels versus electric power ✓ Public transportation and land-use planning	Need a program focused on transportation rather than stove-piped fossil energy, hybrid cars etc. Links between stationary (electric generation) and mobile (vehicles) need to be understood.	Technology transfer likely to be through private industry.
<b>Transformational Technology:</b> In the long run we will need technology not available today. If we add up	Fusion, space based solar, high altitude wind, sustained fusion and microwave transmission to support	Long-term high-risk research program	L20 countries will share risk, e.g. ITER.

everything we think we have or could have with known or nearly ready technology, it isn't enough in the long term.	space based solar, methods to harness biological and genetic scientific advances for energy production		
<b>Developing world:</b> The developing world will experience most of the population growth in the next 50 years and most of the growth in energy demand. The vast majority of this demand will be in India and China. Africa and South America face extreme poverty that will require energy to reverse. The vast majority of the energy sources available in the world come from coal, one of the worst sources of GHG. This problem is especially acute in the developing world.	Need international cooperation to address the environmentally acceptable use of coal. Find ways to use coal as a source of energy in environmentally acceptable ways, i.e. Without releasing GHG or other pollutants into the atmosphere. Finding energy sources for the developing world that are appropriate and environmentally benign.	Many solutions to these problems may involve integrating the energy source with the end use, such as heating, light or communications.	L20 is an important forum for cooperative solutions.